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(54) **Polyolefin composition comprising silicon-containing filler**

(57) The present invention relates to a polyolefin composition comprising a polyolefin base resin comprising an olefin homo- or copolymer (A) having hydrolysable silicon-containing groups, and an inorganic mineral filler

(B) containing on its surface silanol groups or precursors thereof.

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Description

[0001] The present invention relates to a polyolefin composition with improved mechanical strength, especially toughness and impact strength and heat resistance. Especially, the present invention relates to polyolefin compositions wherein a silicon compound-containing filler is strongly embedded in a polyolefin. The present invention further relates to an article made of the polyolefin composition and the use of the polyolefin composition for the production of an article.

[0002] Due to their chemical and thermal resistance as well as their mechanical strength polyolefin compositions are used in various applications such as moulding, film or other applications.

[0003] For demanding applications, e.g. under very low temperature conditions or for heavy duty packaging polyolefins used for these purposes often lack mechanical strength and heat resistance. Therefore, non-polymer reinforcement materials like mineral fillers, glass, or mineral fibres are incorporated in polyolefin compositions as modifiers. However, when using such mineral fillers the mechanical performance of such polyolefin compositions is often limited due to a low adhesion between the polymeric matrix and the filler. Especially the toughness, impact strength and elongation at break is severely lowered in such applications.

[0004] It is known in the prior art to use glass fibre reinforcements where the reinforcement takes place by chemical coupling via surface modification of the fibre with e.g. organosilicon compounds and the addition of a compatibiliser to the polymeric phase. An example for this technology is US 5,910,523 where an aminosilane functionalised filler (e.g. silica) is reacted with carboxyl groups of a carboxylated or maleated polyolefin to form a partially or fully polyolefin functionalised filler. However, such an approach requires specific chemistry and the results in mechanical strength are still poor.

[0005] JP-A-2138353 discloses a polymer composition comprising a propylene homopolymer or an ethylene-propylene copolymer, a silane coupling agent and an inorganic filler.

[0006] It is also known to use a non-treated filler with a polymeric compatibiliser to improve the properties of a polymer, especially polyolefin composition. J. Duchet et al report in J.Appl.Polym.Sci. 65 (1997) 2481-2492 on polyethylene grafting on glass surfaces wherein chlorosilane-terminated polyethylenes with different molar masses were provided to obtain semicrystalline polymers able to crystallise with the free chains of the polyethylene matrix and polymer chains could react with the glass surface. The technique was used for coating of silicon wafer surfaces.

[0007] Another approach in JP2004-051722 disclosing a polyolefin composite resin composition obtained by melt kneading a composition comprising (A) a phyllosilicate, (B) an interlayer dilating agent, and (C) a silane compound having an unsaturated bond and/or a reactive functional group with (D) a polyolefin resin. The melt tension and mouldability is improved by mixing such a specific filler to the polyolefin resin (D).

[0008] However, even in such cases of using surface modified or unmodified fillers mixed into polyolefin resin matrices, problems regarding a highly homogeneous dispersion are still experienced. Moreover, exfoliation is not prevented sufficiently to reach the theoretical potential of the materials. Moreover, the prior art has experienced severe problems when the final polymeric composition is put under mechanical load and/or deformation resulting in debonding and cavitation at the particle surface causing stress whitening and finally fracture of the composition.

[0009] Therefore, it is one object of the present invention to overcome the above problems and to provide a polyolefin composition having improved mechanical characteristics, in particular having improved toughness, impact strength and elongation at break, and improved bonding of the filler particles to the polyolefin matrix or parts thereof.

[0010] The present invention resides in the finding that a mineral filler can easily and safely be bonded to a polymeric matrix so that adhesion between filler and polymer is sharply improved. This can be achieved by chemically binding an inorganic mineral filler containing on its surface silanol groups or precursors thereof to polymer chains of a hydrolysable silicon group-containing polyolefin. Thus, a polyolefin composition improved in mechanical strength, especially toughness, impact strength and elongation at break can be obtained.

[0011] According to a first aspect of the present invention, a polyolefin composition is provided, comprising:

- a polyolefin base resin comprising an olefin homo- or copolymer (A) having hydrolysable silicon-containing groups, and
- an inorganic mineral filler (B) containing on its surface silanol groups or precursors thereof.

[0012] The term polyolefin denotes an olefin homo- or copolymer of a mixture of such olefin homo- or copolymers.

[0013] The polyolefin composition according to the present invention preferably comprises a silanol condensation catalyst capable of cross-linking the hydrolysable silicon group-containing polyolefin (A). Thus, the cross-linking reaction may be preferably carried out at a temperature of not more than 40 °C, more preferably not more than 30 °C, even more preferred at about room temperature. The cross-linking reaction may but need not be conducted in the presence of moisture.

[0014] Basically, the hydrolysable silicon-group containing polyolefin (A) may form a matrix in which the particulate

filler is dispersed. As the polyolefin (A) contained in or forming the base resin an ethylene or propylene homo- or copolymer may be used.

[0015] Preferably, filler (B) is substantially encapsulated by the hydrolysable silicon-group containing polyolefin (A). Thus, the adhesion between filler and polyolefin is guaranteed and the homogeneity of the total composition is improved.

[0016] According to another aspect a heterophasic olefin polymer composition may be provided.

[0017] Thus, according to a preferred embodiment of the present invention the base resin comprises a propylene homo- or copolymer (C) which forms a matrix phase, and a disperse phase which is distributed in said matrix phase and comprises the polyolefin (A) having hydrolysable silicon-containing groups.

[0018] If such a heterophasic olefin polymer composition is provided, it is more preferred that the inorganic mineral filler (B) is present only in the dispersed phase.

[0019] An elastomer is usually and preferably contained in the disperse phase of the heterophasic olefin polymer. Such an elastomer may be any which is typically contained in heterophasic polypropylenes such as an ethylene-propylene copolymer and optionally other alpha-olefin copolymer. Suitable elastomers include ethylene-butene rubber, copolymer rubber such as ethylene-propylene rubber (EPR) or metallocene-catalyst based ethylene plastomers. Elastomer may also be added in the form of ethylene-propylene-diene monomer (EPDM) or styrene-based elastomers (e.g. SEBS). These elastomers can be prepared by conventional processes and blended into the heterophasic polymers of the invention by standard mixing techniques.

[0020] While elastomer and polyolefin (A) may be different polymers, in an embodiment of the invention the olefin homo- or copolymer (A) comprising hydrolysable silicon-containing groups is an elastomer.

[0021] According to this aspect of the present invention, a cross-linked heterophasic polypropylene composition may be provided which is obtainable by a process comprising the steps of:

(i) blending (A), (B) and (C) as defined above, together with a silanol condensation catalyst,

(ii) granulation of the blend of step (i) in a water bath, and afterwards

(iii) cross-linking the obtained heterophasic polypropylene composition at 10 to 40°C under a humidity of below 85 % to a cross-linking degree of at least 30 %, based on the total polyolefin (A).

[0022] The selective cross-linking of the polyolefin phase allows stabilising of the phase morphology of the heterophasic polypropylene composition. The resulting heterophasic polypropylene compositions according to the present invention are additionally characterised by high heat deflection temperatures and improved scratch resistance resulting from the continuous matrix phase as well as a reduced shrinkage and improved surface quality resulting from the cross-linked polyolefin phase.

[0023] Such a heterophasic polypropylene composition preferably has a weight ratio of propylene homo- or copolymer (C) to polyolefin (A) from 97:3 to 45:55, more preferably from 95:5 to 45:55, still more preferably from 90:10 to 50:50, even more preferably from 85:15 to 60:40, and most preferably from 85:15 to 80:20.

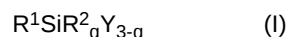
[0024] Furthermore, such a heterophasic polypropylene composition preferably has a weight ratio of propylene homo- or copolymer matrix (C) to the dispersed phase of 95:5 to 45:55, more preferably from 90:10 to 50:50, even more preferably from 85:15 to 60:40.

[0025] Preferably, the inorganic mineral filler (B) is present in the composition in an amount of from 0.5 to 30 wt.%, more preferably from 1 to 25 wt.%, and most preferably from 1.5 to 15 wt.%.

[0026] In the embodiment where polyolefin base resin comprises a matrix and a dispersed phase, preferably at least 90 wt.% of inorganic filler (B) is present in the disperse phase, more preferably at least 95 wt.% and most preferably 100 wt.%.

[0027] The hydrolysable silicon-containing groups can be introduced e.g. by grafting the silicon compound into the polyolefin or by copolymerisation of the olefin monomers and silicon groups containing monomers. Such techniques are known e.g. from US 4,413,066, US 4,297,310, US 4,351,876, US 4,397,981, US 4,446,283 and US 4,456,704.

[0028] In the case the silicon group containing polyolefin (A) has been obtained by copolymerisation, the copolymerisation is preferably carried out with an unsaturated silicon compound represented by the formula



wherein

R^1 is an ethylenically unsaturated hydrocarbyl, hydrocarbyloxy or (meth)acryloxy hydrocarbyl group,

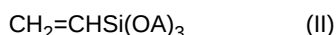
R^2 is an aliphatic saturated hydrocarbyl group,

Y which may be the same or different, is a hydrolysable organic group and

q is 0, 1 or 2.

[0029] Special examples of the unsaturated silicon compound are those wherein R¹ is vinyl, allyl, isopropenyl, butenyl, cyclohexanyl or gamma-(meth)acryloxy propyl; Y is methoxy, ethoxy, formyloxy, acetoxy, propionyloxy or an alkyl- or arylamino group; and R², if present, is a methyl, ethyl, propyl, decyl or phenyl group.

[0030] A preferred unsaturated silicon compound is represented by the formula



wherein A is a hydrocarbyl group having 1-8 carbon atoms, preferably 1-4 carbon atoms.

[0031] The most preferred compounds are vinyl trimethoxysilane, vinyl bismethoxyethoxysilane, vinyl triethoxysilane, gamma-(meth)acryloxypropyltrimethoxysilane, gamma(meth)acryloxypropyltriethoxysilane, and vinyl triacetoxysilane.

[0032] The copolymerisation of the olefin and the unsaturated silane compound may be carried out under any suitable conditions resulting in the copolymerisation of the two monomers.

[0033] Moreover, the copolymerisation may be implemented in the presence of one or more other comonomers which can be copolymerised with the two monomers. Such comonomers include (a) vinyl carboxylate esters, such as vinyl acetate and vinyl pivalate, (b) alpha-olefins, such as propene, 1-butene, 1-hexene, 1-octene and 4-methyl-1-pentene, (c) (meth)acrylates, such as methyl(meth)acrylate, ethyl(meth)acrylate and butyl(meth)acrylate, (d) olefinically unsaturated carboxylic acids, such as (meth)acrylic acid, maleic acid and fumaric acid, (e) (meth)acrylic acid derivatives, such as (meth)acrylonitrile and (meth)acrylic amide, (f) vinyl ethers, such as vinyl methyl ether and vinyl phenyl ether, and (g) aromatic vinyl compounds, such as styrene and alpha-ethyl styrene.

[0034] Amongst these comonomers, vinyl esters of monocarboxylic acids having 1-4 carbon atoms, such as vinyl acetate, and (meth)acrylate of alcohols having 1-4 carbon atoms, such as methyl(meth)-acrylate, are preferred.

[0035] Especially preferred comonomers are butyl acrylate, ethyl acrylate and methyl acrylate.

[0036] Two or more such olefinically unsaturated compounds may be used in combination. The term "(meth)acrylic acid" is intended to embrace both acrylic acid and methacrylic acid. The comonomer content of the copolymer may amount to 70 wt% of the copolymer, preferably about 0.5 to 35 wt%, most preferably about 1 to 30 wt%.

[0037] The grafted polyolefin (A) may be produced e.g. by any of the two methods described in US 3,646,155 and US 4,117,195, respectively.

[0038] The silicon group containing polyolefin (A) according to the invention preferably comprises 0.1 to about 10 wt% of the silicon compound, more preferably 0.5 to 7 wt%, most preferably 1.0 to 4 wt% by weight, based on the total polyolefin (A).

[0039] The silanol content can be adjusted by blending the grafted or copolymerised polyolefin with a non-modified polyolefin.

[0040] If the silicon groups are introduced in the polyolefin (A) by polymerisation, as described above, it is preferred that the silicon group containing polyolefin (A) has a density of 900 to 940 kg/m³, more preferred of 910 to 935 kg/m³, most preferred of 915 to 930 kg/m³.

[0041] Furthermore, it is preferred that the silicon-grafted polyolefin (A) has a density of 920 to 960 kg/m³, more preferred of 925 to 955 kg/m³, most preferred of 930 to 950 kg/m³.

[0042] Moreover, the used polyolefin (A) preferably is an ethylene homo- or copolymer, as a high density polyethylene, low density polyethylene, linear low density polyethylene or their like.

[0043] According to another preferred embodiment a further olefin homo- or copolymer (D) may be present in the disperse phase which is compatible with the elastomer and the polyolefin (A) having hydrolysable silicon-containing groups. Such a further olefin polymer may be a high pressure polyethylene, e.g. a low density polyethylene, or ethylene copolymers like linear low density polyethylene, very low density polyethylene or metallocene-based ethylene plastomer. Addition of said component (D) will further increase toughness and impact strength, especially at temperatures below 0°C, and it will increase the extensibility expressed by the elongation at break.

[0044] The cross-linking reaction may preferably be carried out by any known silanol condensation catalyst. However, it is preferred that the silanol condensation catalyst is typically selected from the group comprising Lewis acids, inorganic acids such as sulphuric acid and hydrochloric acid, and organic acids such as citric acid, stearic acid, acetic acid, sulfonic acid and alkanolic acids as dodecanoic acid, organic bases, carboxylic acids and organometallic compounds including organic titanates and complexes or carboxylates of lead, cobalt, iron, nickel, zinc and tin or a precursor of any of the compounds mentioned.

[0045] Further preferred, the aromatic organic sulfonic acid comprises the structural element:



with Ar being an aryl group which may be substituted or non-substituted, and x being at least 1.

[0046] The organic aromatic sulfonic acid silanol condensation catalyst may comprise the structural unit according to formula (III) one or several times, e.g. two or three times. For example, two structural units according to formula (III)

may be linked to each other via a bridging group such as an alkylene group.

[0047] Preferably, Ar is a aryl group which is substituted with at least one C₄- to C₃₀-hydrocarbonyl group, more preferably C₄- to C₃₀-alkyl group.

[0048] Aryl group Ar preferably is a phenyl group, a naphthalene group or an aromatic group comprising three fused rings such as phenanthrene and anthracene.

[0049] Preferably, in formula (III) x is 1, 2 or 3, and more preferably x is 1 or 2.

[0050] Furthermore, preferably the compound used as organic aromatic sulfonic acid silanol condensation catalyst has from 10 to 200 C-atoms, more preferably from 14 to 100 C-atoms.

[0051] In one preferred embodiment, Ar is a hydrocarbonyl substituted aryl group and the total compound containing 14 to 28 carbon atoms, and still further preferred, the Ar group is a hydrocarbonyl substituted benzene or naphthalene ring, the hydrocarbonyl radical or radicals containing 8 to 20 carbon atoms in the benzene case and 4 to 18 atoms in the naphthalene case.

[0052] It is further preferred that the hydrocarbonyl radical is an alkyl substituent having 10 to 18 carbon atoms and still more preferred that the alkyl substituent contains 12 carbon atoms and is selected from dodecyl and tetrapropyl. Due to commercial availability it is most preferred that the aryl group is a benzene substituted group with an alkyl substituent containing 12 carbon atoms.

[0053] The currently most preferred compounds are dodecyl benzene sulfonic acid and tetrapropyl benzene sulfonic acid.

[0054] The silanol condensation catalyst may also be precursor of the sulfonic acid compound, including all its preferred embodiments mentioned, i.e. a compound that is converted by hydrolysis to such a compound. Such a precursor is for example the acid anhydride of a sulfonic acid compound, or a sulfonic acid that has been provided with a hydrolysable protective group, as e.g. an acetyl group, which can be removed by hydrolysis.

[0055] In a second preferred embodiment, the sulfonic acid catalyst is selected from those as described in EP 1 309 631 and EP 1 309 632, namely

a) a compound selected from the group of

(i) an alkylated naphthalene monosulfonic acid substituted with 1 to 4 alkyl groups wherein each alkyl group is a linear or branched alkyl with 5 to 40 carbons with each alkyl group being the same or different and wherein the total number of carbons in the alkyl groups is in the range of 20 to 80 carbons;

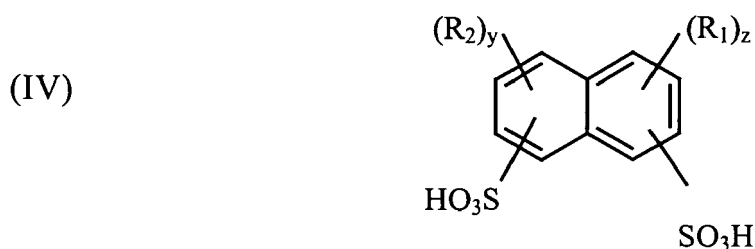
(ii) an arylalkyl sulfonic acid wherein the aryl is phenyl or naphthyl and is substituted with 1 to 4 alkyl groups wherein each alkyl group is a linear or branched alkyl with 5 to 40 carbons with each alkyl group being the same or different and wherein the total number of carbons in the alkyl groups is in the range of 12 to 80;

(iii) a derivative of (i) or (ii) selected from the group consisting of an anhydride, an ester, an acetylate, an epoxy blocked ester and an amine salt thereof which is hydrolysable to the corresponding alkyl naphthalene monosulfonic acid or the arylalkyl sulfonic acid;

(iv) a metal salt of (i) or (ii) wherein the metal ion is selected from the group consisting of copper, aluminium, tin and zinc; and

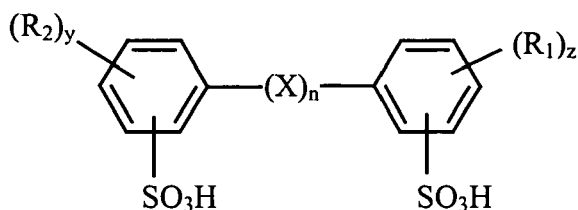
b) a compound selected from the group of

(i) an alkylated aryl disulfonic acid selected from the group consisting of the structure (IV):



and the structure (V):

(V)



wherein each of R_1 and R_2 is the same or different and is a linear or branched alkyl group with 6 to 16 carbons, y is 0 to 3, z is 0 to 3 with the proviso that $y + z$ is 1 to 4, n is 0 to 3, X is a divalent moiety selected from the group consisting of $-C(R_3)(R_4)-$, wherein each of R_3 and R_4 is H or independently a linear or branched alkyl group of 1 to 4 carbons and n is 1; $-C(=O)-$, wherein n is 1; $-S-$, wherein n is 1 to 3 and $-S(O)_2-$, wherein n is 1; and

(ii) a derivative of (i) selected from the group consisting of the anhydrides, esters, epoxy blocked sulfonic acid esters, acetylates, and amine salts thereof which is a hydrolysable to the alkylated aryl disulfonic acid,

together with all preferred embodiments of those sulfonic acids as described in the mentioned European Patents.

[0056] Preferably, in the polyolefin composition the silanol condensation catalyst is present in an amount of 0.0001 to 6 wt%, more preferably of 0.001 to 2 wt%, and most preferably 0.02 to 0.5 wt%. It may also be used in an amount of from 0.05 to 1 wt%.

[0057] Preferably, the cross-linkable polyolefin (A) comprises, still more preferably consists of, a polyethylene containing hydrolysable silicon groups.

[0058] The hydrolysable silicon groups may be introduced into the polyolefin by copolymerisation of e.g. ethylene monomers with silicon group containing comonomers or by grafting, i.e. by chemical modification of the polymer by addition of silicon groups mostly in a radical reaction. Both techniques are well known in the art.

[0059] Moreover, the polyolefin composition according to the invention may further contain various additives, such as miscible thermoplastics, further stabilizers, lubricants, fillers, colouring agents and foaming agents, which can be added before during or after the blending step (i) to the composition.

[0060] As the silanol group-containing inorganic mineral filler (B) any type may be used. However, it is preferred to use a particulate or plate-like filler selected from the group consisting of the group talc, mica, montmorillonite, wollastonite, bentonite, silica, halloysite, kaolinite and other phyllosilicates.

[0061] In contrast to organically modified filler particles combined with a compatibiliser, the inventive polyolefin compositions include an inorganic mineral filler with silanol groups on their surfaces. Instead a group hydrolysable to such a silanol group may be present on the surface of the filler. Such groups are referred herein as "precursors" of silanol groups. These may be coupled by a suitable condensation reaction to hydrolysable silicon groups on the polymer chains of polyolefin (A), preferably with the use of a suitable silanol condensation catalyst as specified above. The reaction may but need not be conducted in the presence of moisture.

[0062] Fig. 1 and Fig. 2 exemplify the difference between the localisation of a filler in a conventional polypropylene impact copolymer where a low density polyethylene forms the disperse phase. It is evident from Fig. 1 that a discrete dispersion separate from the polymeric phases is formed showing that the filler particles are not homogeneously included in the polymeric phase which leads to the above discussed disadvantages.

[0063] On the other hand, Fig. 2 shows a reinforced heterophasic polypropylene composition according to a specifically preferred embodiment of the present invention where the filler particles are homogeneously and completely encapsulated in the dispersed phase which is formed by a polyethylene composition in which silicon functional groups are cross-linked with silanol groups on the surface of the particulate filler. It can be further seen that the filler is present only in the dispersed phase. This specifically preferred structure of the inventive heterophasic polyolefin composition is schematically illustrated in Fig. 3.

[0064] It will be shown in the example section below that the reinforced polyolefin compositions according to the present invention show highly improved mechanical properties such as Charpy notched impact strength, scratch resistance and elongation at break. It was further surprisingly found that the inventive polyolefin compositions showed a significantly reduced gloss achieving an aesthetically attractive surface appearance.

[0065] Thus, the reinforced polyolefin compositions according to the present invention preferably have an impact strength at +23°C of at least 5.5 kJ/m² and at -20°C of at least 2.0 kJ/m² in a Charpy notched impact strength test according to ISO 179 1eA.

[0066] Moreover, the inventive polyolefin compositions preferably have a flexural modulus of not less than 950 MPa, preferably not less than 1000 MPa and even more preferably not less than 1200 MPa, measured according to ISO 178.

[0067] The inventive polyolefin compositions preferably further show an elongation at break of at least 10%, preferably at least 20%, even more preferably at least 50%, measured according to ISO 527.

[0068] The inventive polyolefin compositions preferably show a gloss at 20° of not more than 50%, preferably not more than 40%, even more preferred not more than 30%, measured according to ISO 2813.

[0069] The inventive polyolefin compositions are further improved in scratch resistance. They preferably show a scratch resistance, expressed as delta (L) of at least 3.5, preferably at least 4.0, even more preferred at least 4.5. Scratch resistance is expressed as delta (L) and measured according to the following procedure: A cross hatch grid is cut on the grained surface of an injection-moulded specimen using a steel ball tip tool. The difference in light reflection - delta (L) - is then measured with a spectral photometer.

[0070] The present invention will now be further described by means of the following non-limiting examples and comparative examples, and with reference to the figures.

Fig. 1 shows a conventional polypropylene impact copolymer with a discrete dispersion of a mineral filler separate from the disperse phase.

Fig. 2 shows an embodiment of the polyolefin composition according to the present invention where the mineral filler particles are encapsulated in the disperse phase made of a silicon group containing ethylene vinyl-silane copolymer.

Fig. 3 is a schematic illustration of the embodiment according to Fig. 2.

Examples

1. Definitions

a) Melt Flow Rate

[0071] The melt flow rate (MFR) is determined according to ISO 1133 and is indicated in g/10 min. The MFR is an indication of the flowability, and hence the processability, of the polymer. The higher the melt flow rate, the lower the viscosity of the polymer. The MFR₂ of polypropylene is determined at a temperature of 230 °C and a load of 2.16 kg, the MFR₅ of polyethylene is measured at a temperature 190 °C and a load of 5 kg and the MFR₂ of polyethylene at a temperature 190 °C and a load of 2.16 kg.

b) Xylene insolubles

[0072] The content of xylene hot insolubles is determined by extracting 1 g of finely cut polymer sample with 500 ml xylene in a Soxhlet extractor for 48 hours at the boiling temperature. The remaining solid amount is dried at 90 °C and weighed for determining the insolubles amount.

c) Charpy notched impact test

[0073] The impact strength is determined as Charpy Impact Strength according to ISO 179 1 eA at +23°C and at -20 °C on injection moulded specimens of 80x10x4 mm³.

d) Tensile test

[0074] Tensile tests are performed according to ISO 527 using injection moulded specimen as described in EN ISO 1873-2 (dog bone shape, 4 mm thickness).

[0075] Tensile modulus (E-modulus) was also determined according to ISO 527 and calculated from the linear part of the tensile test results.

e) Flexural Modulus

[0076] The flexural modulus is measured according ISO 178 using injection moulded specimens of 80 x 10 x 4 mm³.

f) Density

[0077] The density is measured according to ISO 1183.

g) Elongation at break

[0078] The elongation at break was also determined according to ISO 527.

h) Gloss

[0079] Gloss was determined on injection moulded specimens of 60 x 60 x 2 mm³ according to ISO 2813.

i) Scratch resistance

[0080] A plate of 3 mm thickness with a fine-grained surface (type N111) is produced by injection moulding. With an Erichsen Cross Hatch Cutter model 420p, a cross hatch grid of 40 x 40 mm² (line distance 2 mm in both directions) is cut on the grained surface using the standardised Erichsen steel ball tip tool (1 mm diameter) with a force of 10 N and a cutting speed of 1000 mm/min. The difference in light reflection - delta (L) - is then measured with a spectral photometer. Better scratch resistance is expressed by lower scratch visibility and correspondingly a smaller delta(L) value

2. Materials

[0081] The components - propylene homo- or copolymer, polyethylene-vinylsilane-copolymer or grafting product and the catalyst master batch (Borealis polyethylene CAT-MB50 or CAT-MB 25 with dibutyltin dilaurate as catalytically active substance), were combined in a twin screw extruder (PRISM TSE24, L/D ratio 40) with two high intensity mixing segments at temperatures between 190 and 220°C at a through put off of 10 kg/h and a screw speed of 50 rpm. The material was extruded to two circular dies of 3mm diameter into water base with a residence time of at least 30 sec for solidifying the melt standard, which was consequently granulated. For the period until melt processing, the resulting compound was stored at an ambient temperature of + 23 ± 2 °C and normal humidity (50 ± 5%).

[0082] Masterbatch compositions were produced as follows:

(a) 50 wt.% of an ethylene-propylene random copolymer with MFR (230°C/2.16 kg) of 8 g / 10 min, an ethylene content of 6 wt% and a density of 905 kg/m³. were blended with 47.5 wt% silicon group containing polyethylene LE4481 and 2.5 wt% CAT-MB50, or

(b) 75 wt.% of the same ethylene-propylene random copolymer were blended with 23.75 wt % silicon group containing polyethylene LE4481 and 1.25 wt% CAT-MB25,

to obtain two masterbatch compositions containing (a) 50 wt.% and (b) 25 wt% of the silicon group-containing polyethylene.

Compounds:

[0083] All used polymers are commercially available by Borealis Polyolefine GmbH:

PPX104 is a heterophasic propylene-ethylene copolymer with MFR (230°C/2.16 kg) of 31 g / 10 min, an EPR content of 20 wt% and a density of 905 kg/m³.

BG055A1 is a heterophasic propylene-ethylene impact copolymer with MFR (230°C/2.16 kg) of 22 g / 10 min, an EPR content of 18 wt% and a density of 905 kg/m³.

FB5150 is a linear low density polyethylene (LLDPE) with MFR (190°C/2.16 kg) of 1.5 g / 10 min , and a density of 915 kg/m³.

FT7239 is a low density polyethylene (LDPE) with MFR (190°C/2.16 kg) of 3 g / 10 min, and a density of 929 kg/m³.

HE2545 is a silane-grafted high density polyethylene (HDPE) with MFR (190°C/2.16kg) of 6 g / 10 min, a density of 955 kg/m³ and a silanol content of 1.5 wt%.

Visico LE4481 is a high-pressure low density ethylene copolymer with vinyl silane content for cable insulation with MFR (190°C/2.16 kg) of 5 g / 10 min , a silanol content of 1.75 wt% and a density of 927 kg/m³.

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Visico LE4423 is a high-pressure low density ethylene copolymer with vinyl silane content for cable insulation with MFR (190°C/2.16 kg) of 1 g / 10 min , a silanol content of 1.35 wt% and a density of 923 kg/m³.

"Talc" is Tital 15, manufactured by Ankerpoort NV having a top-cut particle size of 7 µm (95% of particles below that size, according to ISO 787-7) and a weight average particle size of 2 µm as determined according to ISO 13317-1.

Example 1:

[0084] 87.75 wt% PPX104 as matrix phase, 2.0 wt% LE4481 as silane-copolymerised polyethylene, 10.0 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Example 2:

[0085] 87.75 wt% PPX104 as matrix phase, 2.0 wt% LE4423 as silane-copolymerised polyethylene, 10.0 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Example 3:

[0086] 84.75 wt% PPX104 as matrix phase, 5.0 wt% LE4423 as silane-copolymerised polyethylene, 10.0 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Example 4:

[0087] 79.75 wt% PPX104 as matrix phase, 10.0 wt% LE4423 as silane-copolymerised polyethylene, 10.0 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Example 5:

[0088] 79.75 wt% PPX104 as matrix phase, 5.0 wt.% FB5150, 5.0 wt% LE4423 as silane-copolymerised polyethylene, 10.0 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Example 6:

[0089] 79.75 wt% BG055A1 as matrix phase, 10.0 wt% HE2545 as silane-grafted polyethylene, 2.5 wt.% talc and 0.25 wt% catalyst master batch CAT-MB50 are used.

Comparative Example 1:

[0090] Only PPX 104 is used.

Comparative Example 2:

[0091] 90.0 wt% PPX104 without additional dispersed phase, and 10.0 wt.% talc are used.

Comparative Example 3:

[0092] 80.0 wt% PPX104 as matrix phase, 10.0 wt% FT7239 as a dispersed polyethylene without silane groups, and 10.0 wt.% talc are used.

Comparative Example 4:

[0093] 90.0 wt% BG055A1 and 10.0 wt.% talc are used.

[0094] The results are shown in Table 1 below.

Table 1

	Base polymer -	Filler type -	amount wt%	PE type -	amount wt%	PE-SiOX type -	amount wt%	MFR 230°C/ 2,16kg g/10min	Flex.Test* Modulus MPa	Charpy NIS**		Gloss 20° %	Scratch Delta(L) -
										+ 23°C kJ/m ²	- 20°C kJ/m ²		
EX1	PPX104	tal ^{***}	10	none	0	LE4481	2	23	1071	7,0	3,7	30	4,6
EX2	PPX104	tal ^{***}	10	none	0	LE4423	2	23	1192	6,6	3,5	30	4,5
EX3	PPX104	tal ^{***}	10	none	0	LE4423	5	20	1008	6,8	3,8	19	4,3
EX4	PPX104	tal ^{***}	10	none	0	LE4423	10	16	970	8,1	3,9	14	3,9
EX5	PPX104	tal ^{***}	10	FB5150	5	LE4423	5	21	1009	8	3,8	20	3,8
EX6	BG055AI	tal ^{***}	2,5	none	0	HE2545	10	14,7	1602	5,6	2	-	-
CE1	PPX 104	none	0	none	0	none	0	31	1042	5,0	2,6	62	2,2
CE2	PPX 104	tal ^{***}	10	none	0	none	0	25	1635	5,1	2,4	41	4,8
CE3	PPX 104	tal ^{***}	10	FT7239	10	none	0	22	1456	5,8	2,7	38	4,5
CE4	BG055AI	tal ^{***}	2,5	none	0	none	0	20	1923	4,3	1,7	-	-

* ISO 178 *** Tita115 from Ankerpoort NV, top cut 7 µm

** ISO 179 1eA

PPX 104 - Experimental PP grade with 20 wt% EPR

LE4481 - "Visico" type high pressure VTMS copolymer, density 927 kg/m³

LE4423 - "Visico" type high pressure VTMS copolymer, density 923 kg/m³

FT7239 - LDPE, density 0.929

FB5150 - LLDPE, density 0.915

BG055AI - PP impact copolymer

HE2545 - VTMS-grafted HDPE, density 955 kg/m³

Claims

1. A polyolefin composition comprising:

- a polyolefin base resin comprising an olefin homo- or copolymer (A) having hydrolysable silicon-containing groups, and
- an inorganic mineral filler (B) containing on its surface silanol groups or precursors thereof.

2. The polyolefin composition according to claim 1, wherein said composition further comprises a silanol condensation catalyst.

3. The polyolefin composition according to claim 2, wherein the silanol condensation catalyst is selected from the group consisting of inorganic acids such as sulphuric acid and hydrochloric acid, organic acids such as citric acid, stearic acid, acetic acid, sulphonic acid and alkanolic acids as dodecanoic acid, organic bases, carboxylic acids, organo-metallic compounds including organic titanates and complexes or carboxylates of lead, cobalt, iron, nickel, zinc and tin or a precursor of these compounds.

4. The polyolefin composition according to any of claims 1 to 3, wherein the hydrolysable silicon group-containing olefin homo- or copolymer (A) is an ethylene homo- or copolymer.

5. The polyolefin composition according to any of the preceding claims, wherein the polyolefin base resin further comprises a propylene homo- or copolymer (C) which forms a matrix phase, and a disperse phase which is dispersed in said matrix phase and comprises the olefin homo- or copolymer (A) having hydrolysable silicon-containing groups.

6. The polyolefin composition according to claim 5, wherein the disperse phase further comprises an elastomer.

7. The polyolefin composition according to claim 5 or 6, wherein the inorganic mineral filler (B) is present only in the disperse phase.

8. The polyolefin composition according to any of claims 5 to 7, wherein the composition is obtainable by a process for the preparation of a crosslinked heterophasic polypropylene composition, comprising the steps of:

- i. blending (A) and (C) together with a silanol condensation catalyst,
- ii. granulation of the blend of step (i) in a water bath, and afterwards
- iii. cross-linking the obtained heterophasic polypropylene composition at 10 to 40 °C under a humidity of below 85 % to a cross-linking degree of at least 30 %, based on the total olefin homo- or copolymer (A).

9. The polyolefin composition according to claim 8, wherein step (i) is carried out at a temperature of 180 to 230 °C.

10. The polyolefin composition according to claim 8, wherein for granulation the residence time of the blend of step (i) in the water bath is less than 30 seconds.

11. The polyolefin composition according to any of claims 5 to 10, wherein the weight ratio of propylene homo- or copolymer (C) to olefin homo- or copolymer (A) is from 95:5 to 45:55.

12. The polyolefin composition according to any of the preceding claims, wherein the amount of the silicon-containing groups is from 0.1 to about 50 wt%, based on the total olefin homo- or copolymer (A).

13. The polyolefin composition according to any of the preceding claims, wherein olefin homo- or copolymer (A) is silicon-grafted and has a density of 920 to 960 kg/m³.

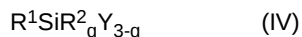
14. The polyolefin composition according to any of claims 1 to 13, wherein olefin homo- or copolymer (A) is obtained by a polymerisation of olefin monomers and silicon group-containing monomers and has a density of 900 to 940 kg/m³.

15. The polyolefin composition according to any of the preceding claims, wherein the inorganic mineral filler (B) is selected from the group consisting of talc, mica, montmorillonite, wollastonite, bentonite, silica, and phyllosilicate.

16. The polyolefin composition according to any of claims 5 to 16, wherein the disperse phase comprises a further olefin

homo- or copolymer (D) compatible with the olefin homo- or copolymer (A).

- 5 17. The polyolefin composition according to any of the preceding claims, wherein the hydrolysable silicon-containing groups are introduced into the olefin homo- or copolymer (A) by copolymerisation with an unsaturated silicon-compound represented by the formula:



wherein

10 R¹ is an ethylenically unsaturated hydrocarbyl, hydrocarbyloxy or (meth)acryloxy hydrocarbyl group,

R² is an aliphatic saturated hydrocarbyl group,

Y which may be the same or different, is a hydrolysable organic group and

q is 0, 1 or 2.

- 15 18. The polyolefin composition according to any of the preceding claims, wherein the composition has been subjected to the presence of moisture.

19. The polyolefin composition according to any of the preceding claims, wherein the composition has an impact strength at + 23 °C of at least 5.5 kJ/m² in a Charpy notched test according to ISO 179 1eA.

- 20 20. The polyolefin composition according to any of the preceding claims, wherein the composition has an impact strength at -20 °C of at least 2.0 kJ/m², in a Charpy notched test according to ISO 179 1eA.

- 25 21. The polyolefin composition according to any of the preceding claims, wherein the composition has a flexural modulus of not less than 950 MPa, measured according to ISO 178.

22. The polyolefin composition according to any of the preceding claims, wherein the composition has an elongation at break of at least 10%, preferably at least 20%, measured according to ISO 527.

- 30 23. The polyolefin composition according to any of the preceding claims, wherein the composition has a scratch resistance, expressed as delta (L) of at least 3.5, preferably at least 4.0.

24. An article made of the polyolefin composition according to any of claims 1 to 22.

- 35 25. Use of the polyolefin composition according to any of claims 1 to 22 for the production of an article.

Amended claims in accordance with Rule 137(2) EPC.

- 40 1. A polyolefin composition comprising:

- a polyolefin base resin comprising an olefin homo- or copolymer (A) having hydrolysable silicon-containing groups, and
- an inorganic mineral filler (B) containing on its surface silanol groups or precursors thereof,

45 wherein the amount of the silicon-containing groups is from 0.1 to about 10 wt%, based on the total olefin homo- or copolymer (A).

- 50 2. The polyolefin composition according to claim 1, wherein said composition further comprises a silanol condensation catalyst.

3. The polyolefin composition according to claim 2, wherein the silanol condensation catalyst is selected from the group consisting of inorganic acids such as sulphuric acid and hydrochloric acid, organic acids such as citric acid, stearic acid, acetic acid, sulphonic acid and alkanolic acids as dodecanoic acid, organic bases, carboxylic acids, organometallic compounds including organic titanates and complexes or carboxylates of lead, cobalt, iron, nickel, zinc and tin or a precursor of these compounds.

4. The polyolefin composition according to any of claims 1 to 3, wherein the hydrolysable silicon group-containing

olefin homo- or copolymer (A) is an ethylene homo- or copolymer.

5. The polyolefin composition according to any of the preceding claims, wherein the polyolefin base resin further comprises a propylene homo- or copolymer (C) which forms a matrix phase, and a disperse phase which is dispersed in said matrix phase and comprises the olefin homo- or copolymer (A) having hydrolysable silicon-containing groups.

6. The polyolefin composition according to claim 5, wherein the disperse phase further comprises an elastomer, different from the olefin homo- or copolymer (A).

7. The polyolefin composition according to claim 5 or 6, wherein the inorganic mineral filler (B) is present only in the disperse phase.

8. The polyolefin composition according to any of claims 5 to 7, wherein the composition is obtainable by a process for the preparation of a crosslinked heterophasic polypropylene composition, comprising the steps of:

- i. blending (A) and (C) together with a silanol condensation catalyst,
- ii. granulation of the blend of step (i) in a water bath, and afterwards
- iii. cross-linking the obtained heterophasic polypropylene composition at 10 to 40 °C under a humidity of below 85 % to a cross-linking degree of at least 30 %, based on the total olefin homo- or copolymer (A).

9. The polyolefin composition according to claim 8, wherein step (i) is carried out at a temperature of 180 to 230 °C.

10. The polyolefin composition according to claim 8, wherein for granulation the residence time of the blend of step (i) in the water bath is less than 30 seconds.

11. The polyolefin composition according to any of claims 5 to 10, wherein the weight ratio of propylene homo- or copolymer (C) to olefin homo- or copolymer (A) is from 95:5 to 45:55.

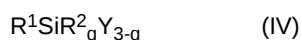
12. The polyolefin composition according to any of the preceding claims, wherein olefin homo- or copolymer (A) is silicon-grafted and has a density of 920 to 960 kg/m³.

13. The polyolefin composition according to any of claims 1 to 12, wherein olefin homo- or copolymer (A) is obtained by a polymerisation of olefin monomers and silicon group-containing monomers and has a density of 900 to 940 kg/m³.

14. The polyolefin composition according to any of the preceding claims, wherein the inorganic mineral filler (B) is selected from the group consisting of talc, mica, montmorillonite, wollastonite, bentonite, silica, and phyllosilicate.

15. The polyolefin composition according to any of claims 5 to 14, wherein the disperse phase comprises a further olefin homo- or copolymer (D) compatible with the olefin homo- or copolymer (A), the olefin homo- or copolymer (D) being selected from high pressure polyethylenes or metallocene-based ethylene plastomers.

16. The polyolefin composition according to any of the preceding claims, wherein the hydrolysable silicon-containing groups are introduced into the olefin homo- or copolymer (A) by copolymerisation with an unsaturated silicon-compound represented by the formula:



wherein

R¹ is an ethylenically unsaturated hydrocarbyl, hydrocarbyloxy or (meth)acryloxy hydrocarbyl group,

R² is an aliphatic saturated hydrocarbyl group,

Y which may be the same or different, is a hydrolysable organic group and

q is 0, 1 or 2.

17. The polyolefin composition according to any of the preceding claims, wherein the composition has been subjected to the presence of moisture.

18. The polyolefin composition according to any of the preceding claims, wherein the composition has an impact strength at + 23 °C of at least 5.5 kJ/m² in a Charpy notched test according to ISO 179 1 eA.

19. The polyolefin composition according to any of the preceding claims, wherein the composition has an impact strength at -20 °C of at least 2.0 kJ/m², in a Charpy notched test according to ISO 179 1 eA.

20. The polyolefin composition according to any of the preceding claims, wherein the composition has a flexural modulus of not less than 950 MPa, measured according to ISO 178.

21. The polyolefin composition according to any of the preceding claims, wherein the composition has an elongation at break of at least 10%, measured according to ISO 527.

22. The polyolefin composition according to claim 21, wherein the composition has an elongation at break of at least 20%, measured according to ISO 527.

23. The polyolefin composition according to any of the preceding claims, wherein the composition has a scratch resistance, expressed as delta (L) of at least 3.5, preferably at least 4.0.

24. An article made of the polyolefin composition according to any of claims 1 to 23.

25. Use of the polyolefin composition according to any of claims 1 to 23 for the production of an article.

Fig.1:

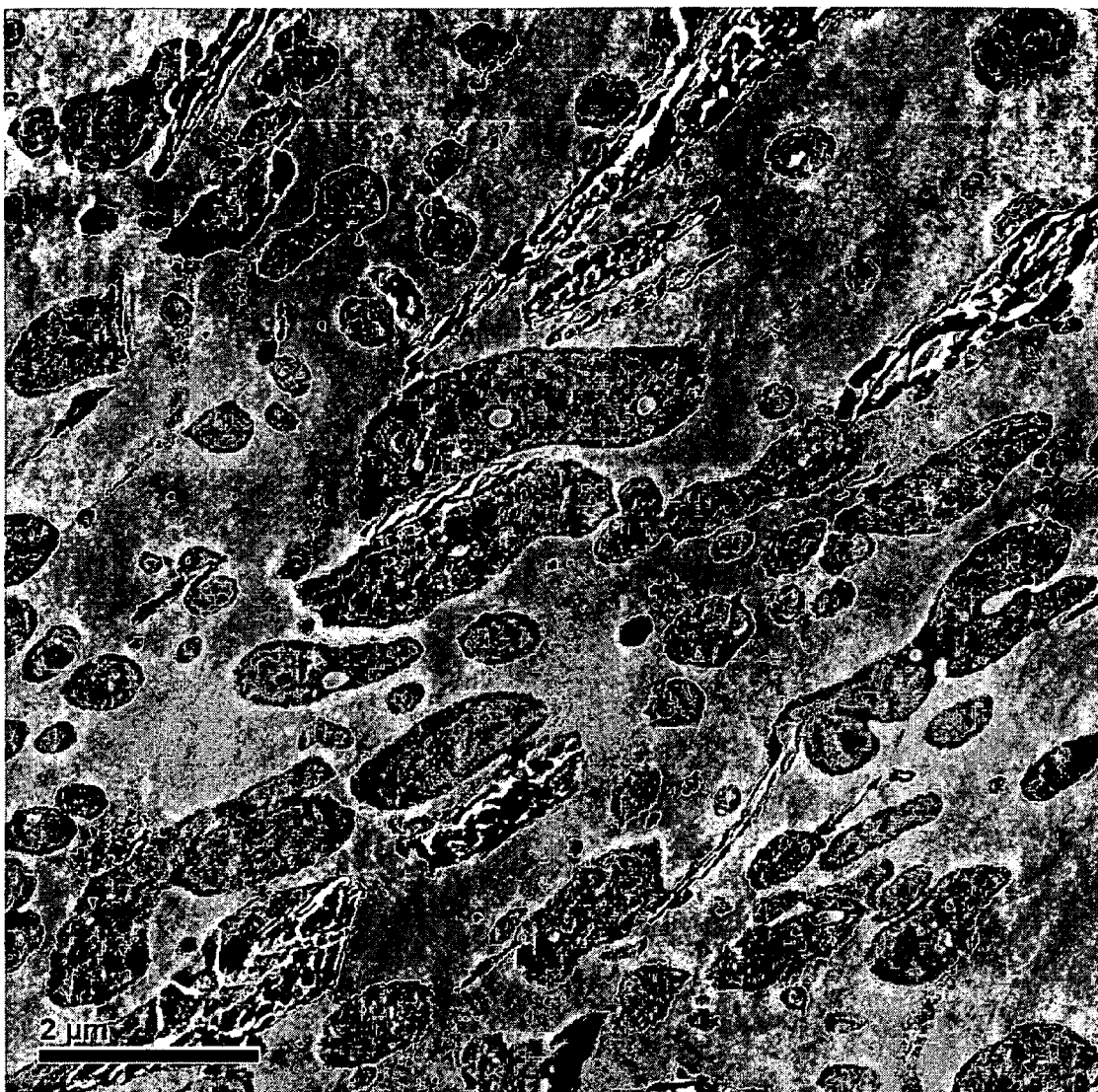
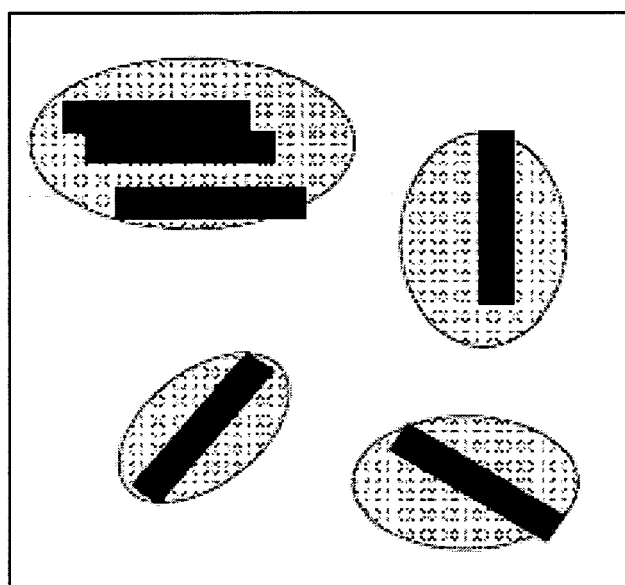


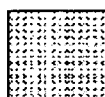
Fig.2:



Fig.3:



Matrix (PP)



Disperse elastomer
(PE/EPR)



Mineral



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 02 7118

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Place of search The Hague		Date of completion of the search 27 April 2007	Examiner Bergmans, Koen
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